PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventor: ALFRED HERBERT WALTER LOYNES

880,903

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COMPLETE SPECIFICATION

Improvements in or relating to Turbines

We, DOWTY ROTOL LIMITED, a British Company, of Arle Court, Cheltenham in the County of Gloucester, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to turbines, and concerns turbines of the kind (hereinafter termed the kind referred to) having inlet nozzle means comprising a ring of pivoted nozzle vanes, simultaneously adjustable as to incidence, to vary the effective nozzle inlet area to the turbine.

With turbines of this kind it has been found that under the effect of high operating temperatures distortion of the turbine casing and/or parts of the operating mechanism employed for adjusting the incidence of the nozzle vanes can cause one or more of the pivoted vanes to jam, such jamming stalling the operating mechanism, and preventing the other vanes from being adjusted. If this happens, speed control of the turbine cannot be achieved.

The object of the invention is to provide in a turbine an improved construction of nozzle means of the kind comprising pivoted vanes whereby, during operation, distortion of the turbine casing or nozzle vane operating mechanism is permitted within reasonable limits without jamming of the nozzle vanes occurring.

According to the invention there is provided a turbine of the kind referred to, wherein the nozzle vanes project across a passageway in the turbine casing leading to the turbine rotor, said passageway being defined between a pair of opposed walls, the nozzle vanes projecting from one of said walls towards the other wall and into engagement with a sealing member carried from said other wall of the turbine casing by resilient means urging said sealing member into sealing engagement with the nozzle vanes, which resilient means permits limited movement of said sealing member with respect to the turbine casing and constitutes sealing means between said sealing member and said other wall.

In the application of the invention to a turbine wherein said passageway is a radial flow passageway, the sealing member is preferably in the form of a flat ring, and preferably also said resilient means comprises a frusto-conical spring washer positioned behind the sealing member.

One embodiment of the invention will now be described, by way of example, with reference to the drawings accompanying the provisional specification, of which,

Figure 1 is a part-sectional view of an air turbine according to the invention, and

Figure 2 shows a part-sectional end elevation of the air turbine along the line X—X in Figure 1.

Referring to the drawings, the turbine is an inward radial flow turbine having an axially directed exhaust passage 14. The turbine comprises a rotor 11 mounted on a shaft 20 for rotation in anti-friction bearings one of which is shown at 12.

The rotor 11 has a spinner 13 which ensures a smooth exit for the expanding air passing through the turbine rotor 11 into the exhaust passage. The exhaust passage is bounded by a substantially cylindrical casing part 15 formed integrally with the main turbine casing 16. A flange 17 on the part 15 provides a connection for a turbine exhaust pipe. The casing 16 encloses a substantially annular inlet scroll 18 having a coupling flange 19 for the connection of an air supply duct. An annular member 21, having a ring of equally spaced bores 22 is secured to the inlet scroll 18, the axes 23 of the bores 22 being parallel with the axis of the rotor 11. An annular closure

casing 24 is bolted to the scroll 18 and member 21, the casing 24 enclosing an annular chamber 27 on the side of the member 21 remote from the inlet scroll, and then extending inwardly in close proximity to one face, the right-hand face in Figure 1, of the rotor 11, to an inner peripheral diameter adjacent which it carries a ring 28, which, with a radially inner stepped part of the member 24 retains the outer race of the ball-bearing 12. An annular labyrinth 29 is bolted as at 30 to the casing 24 and co-operates with the rotor 11 to prevent leakage of air radially inwardly between the rotor and the casing 24.

In the particular construction now being described there are twenty-five bores 22 in the member 21, in each of which is rotatably mounted a variable incidence nozzle vane assembly one of which is generally indicated at 31 in Figure 1. Each nozzle vane assembly comprises an aerofoil sectioned vane 32 which projects across an annular radial flow passageway 33, which leads from the interior of the inlet scroll 18 to the periphery of the turbine rotor 11. As may be seen from Figure 1 the passageway 33, is defined between opposed walls 33*a* and 33*b* one of which, 33*a*, is constituted by the member 21 and the other of which is formed by part of the main casing 16. The vanes 32 project from the wall 33*a* towards the wall 33*b* of the passageway, the vanes being arranged in a ring surrounding the inlet to the rotor 11. Each nozzle vane has a circular root part 34 which lies in the mouth of the bore 22 in which the nozzle vane is mounted and closes the bore, a suitable sealing ring 35 being provided in each case. Integral with the root part 34 is a hollow stem 36 which extends through the bore into the chamber 27. The stem 36 is carried by ball-bearings 37 and 38 spaced apart by sleeves 39 and 40. A forked lever 41 is dowelled to the stem 36 by a dowel 42, and a unison ring 43, of channel cross-section, having twenty-five circumferentially equally spaced notches 44, cooperates with all the levers 41 each of the notches engaging with a pin 45 provided across the forks of one of the levers 41. The unison ring 43 is angularly displaceable by any convenient actuator mechanism (not shown) to adjust the incidence of the nozzle vanes 32. A speed governor is usually employed for this purpose.

As may be seen from Figure 2, the vanes have a limiting position shown in broken lines in which they shut together so as to close the inlet to the rotor. Rotation of the vanes from this position increases the inlet area to the rotor in well known manner, adjacent pairs of vanes then forming a nozzle through which air expands in passing to the rotor to drive the rotor.

Each nozzle vane 32 projects from the wall 33*a* into engagement with a sealing member in the form of a flat ring 46 which is housed with clearance in an annular recess 47 in the wall 33*b*.

At its downstream peripheral edge, that is to say its inner diameter in the present example, and on its rear face, the ring 46 has an undercut lip 50 which receives the downstream peripheral edge of a large diameter frusto-conical spring washer 51, generally termed a "Belleville" washer. In this manner the ring 46 is joined to the washer in a gastight manner with the washer lying in the recess 47 behind the ring 46, the ring and the washer diverging in the upstream direction of the passage 33. The washer 51 is a push fit in the recess 47 around its upstream peripheral edge, that is to say its outer diameter in the present example, the washer thereby being retained in the recess 47 in sealing engagement with the wall of the recess around its outer diametrical edge. Thus the washer 51 carries the ring 46 from the casing 16, the washer also providing a seal between the ring 46 and the casing. Around its outer diametral edge the washer 51 has an annular peripheral edge portion which lies in contact with an annular step 47*a* in the rear wall of the recess. This assists in sealing the washer to the wall of the recess to prevent the passage of air around the back of the washer from the inlet scroll into the rotor chamber. Before assembly of the vanes 32 into engagement with the ring 46 but within the recess 47, it is arranged that the ring 46 stands 0.025 inches proud into the passageway 33.

When, however the vanes are fitted and engage the ring 46, the ring 46 is held by the vanes, against the action of the washer 51, flush with the wall 33*b* of passageway 33. The ring 46 is therefore urged into engagement with the vane tips and sealing of each vane is thereby ensured.

By virtue of the limited movement of the member 46 which is permitted by the arrangement described, distortion of the inlet scroll and/or of the vane assembly itself is accommodated to a sufficient degree to guard against jamming of the vanes at least by such distortions as can more commonly be expected.

A number of passageways 52 place the interior of the inlet scroll 18 in communication with the annular chamber 27 so that the chamber 27 is subjected to the same pressure as the inlet scroll, the pressure in the chamber 27 acting in effect on the total area of the rear face of the root parts 34. The same pressure also acts on that part of the other face of root parts 34 which lie upstream of the vanes 32 and also on that part of the front face of the ring 46 which lies upstream of the vanes 32. The inlet pressure is also communicated through the clearance 48 between the upstream peripheral edge of the ring 46 and the recess 47 to substantially the whole of the rear face of the ring 46 and the front face of the washer 51. The actual pressure acting on

the remaining areas of the front face of the root parts 34 and the front face of the ring 46 is progressively less with movement across the vanes by virtue of the pressure drop across the vanes. The vane outlet pressure is communicated through the clearance 49 between the downstream peripheral edge of the ring 46 and the recess 47 to a substantial proportion of the rear face of the washer 51.

The dimensions of the root parts 34, ring 46, and the washer 51 are, in the present example, so chosen that the counteracting pressures together with the spring force in the washer produce a resultant load of two pounds weight between the ring 46 and the tips of the vanes 32 this load urging the ring 46 and the vane tips together to provide a seal between them.

It will be appreciated that it is important to provide an adjustable seal between the vane tips and the ring 46, and also between the ring 46 and the wall 33*b* of the passage 33 because when the turbine is inoperative i.e. with all the vanes closed as shown in dotted lines in Figure 2, any leakage of air from the inlet scroll to the rotor would tend to drive the rotor under conditions in which it is required to remain stationary.

It will be appreciated that the washer 51 may be replaced by any other convenient form of resilient ring member and more than one such ring member could be provided interposed between the ring 46 and the rear wall of the recess 47. Such ring members could be retained for example in grooves in the ring 46 and the recess respectively, the ring members forming a satisfactory seal behind the ring 46.

In the latter case the inlet pressure could be communicated to the rear face of the ring 46 through suitable passages in the main casing.

WHAT WE CLAIM IS:—

1. A turbine of the kind referred to, wherein the nozzle vanes project across a passageway in the turbine casing leading to the turbine rotor, said passageway being defined between a pair of opposed walls, the nozzle vanes projecting from one of said walls towards the other wall and into engagement with a sealing member carried from said other wall of the turbine casing by resilient means urging said sealing member into sealing engagement with the nozzle vanes, which resilient means permits limited movement of said sealing member with respect to the turbine casing and constitutes sealing means between said sealing member and said other wall.

2. A turbine as claimed in claim 1, wherein said passageway is a radial flow passageway, and said sealing member is in the form of a flat ring.

3. A turbine as claimed in claim 2, wherein said resilient means comprises a frusto-conical spring washer positioned behind the sealing member.

4. A turbine as claimed in claim 3, wherein the sealing member is joined at its downstream peripheral edge to the downstream peripheral edge of said washer in a gas-tight manner, the washer and the sealing member diverging in the upstream direction.

5. A turbine as claimed in claim 4, wherein the sealing member has an undercut lip extending around its downstream peripheral edge on its side adjacent said washer and the downstream peripheral edge of said washer is received under said lip, the sealing member being thereby joined and sealed to the washer at its downstream edge.

6. A turbine as claimed in any of claims 1 to 5 wherein said sealing member is housed with clearance in an annular recess in said other wall.

7. A turbine as claimed in claim 6 taken in conjunction with any of claims 3 to 5, wherein at its upstream peripheral edge, said washer is a push fit in said recess, the washer thereby being retained in the recess in sealing engagement with a wall thereof.

8. A turbine as claimed in claim 7, wherein, at its upstream peripheral edge, said washer has an annular peripheral edge portion which lies in contact with an annular step in the rear wall of said recess.

9. A turbine of the kind referred to, constructed and arranged substantially as hereinbefore described with reference to, and as shown in, the drawings accompanying the provisional specification.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.1.
Chartered Patent Agents,
Agents for the Applicants.

PROVISIONAL SPECIFICATION

Improvements in or relating to Turbines

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With turbines of this kind it has been found that under the effect of high operating temperatures distortion of the turbine casing and/or parts of the operating mechanism employed for adjusting the incidence of the nozzle vanes can cause one or more of the pivoted vanes to jam, such jamming stalling

the operating mechanism, and preventing the other vanes from being adjusted. If this happens speed control of the turbine cannot be achieved.

The object of the invention is to provide in a turbine an improved construction of nozzle means of the kind comprising pivoted vanes whereby, during operation, distortion of the turbine casing or nozzle vane operating mechanism is permitted within reasonable limits without jamming of the nozzle vanes occurring.

According to the invention there is provided a turbine of the kind described wherein the nozzle vanes project across a passageway in the turbine casing leading to the turbine rotor, said passageway being defined between a pair of opposed walls, the nozzle vanes projecting from one of said walls towards the other wall and into engagement with a sealing member carried from the turbine casing by resilient means urging said sealing member into sealing engagement with the nozzle vanes, said resilient means permitting limited tilting of said sealing member with respect to the turbine casing, and sealing means being provided between said sealing member and said other wall.

Preferably said sealing member is carried from said other wall by said resilient means, the resilient means constituting said sealing means.

One embodiment of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, of which,

Figure 1 is a part-sectional view of an air turbine according to the invention, and

Figure 2 shows a part-sectional end elevation of the air turbine along line XX in Figure 1.

Referring to the drawings, the turbine comprises a turbine rotor 11 mounted for rotation in suitable anti-friction bearings. For convenience only one such bearing 12 is shown in the drawing, but of course, further bearings may be povided if so desired.

The rotor 11 is provided with a spinner 13 which ensures a smooth exit for the expanding air passing through the turbine rotor 11 into the exhaust passage 14. This passage is bounded by a substantially cylindrical part 15 leading from and integral with the main part of the turbine casing 16. At its downstream end, the part 15 is provided with a flange 17 for connection to a duct (not shown) which conveys the exhaust to atmosphere. The casing 16 is provided with a substantially annular inlet scroll 18 having a flanged part 19 for connection to a supply duct (not shown), which carries compressed air from a suitable source, (e.g. a tapping from the compressor of a gas turbine engine), to the turbine. The shaft 20 upon which the turbine rotor 11 is mounted extends to the right in the drawing, and may, for example, drive an alternator or any other desired rotary machine. The air turbine and say an alternator may be combined into one integral turbo-alternator unit. In such a case only two main bearings would be required for the unit, one between the turbine and alternator, and one at the other end of the alternator. An annular casing member 21 is secured to the right-hand side of the inlet scroll 18, this member being suitably provided with a number of circumferentially equally spaced bores 22. The axes 23 of these bores are parallel with the axis of the turbine rotor 11 and the shaft 20. A closure casing 24 is secured by means of a number of bolts 25 and nuts 26 with the scroll 18 and member 21, and is shaped such that an annular chamber 27 is provided to the right of the member 21. The radially inner part of casing 24 however, is disposed in close proximity to the right-hand face of the turbine rotor 11. Bolted to the casing 24 near its inner diameter is a ring member 28, members 24 and 28 being so shaped as to retain the outer race of the ball-bearing 12 between them. The inner race of the ball-bearing is retained in convenient manner on the turbine rotor shaft 20. An annular labyrinth member 29 is retained upon the left-hand face of the closure casing 24 by means of a ring of bolts 30. This labyrinth member co-operates with the right-hand face of the turbine rotor 11 to prevent leakage of air radially inwardly past it.

In a particular construction it has been found convenient to provide twenty-five bores 22 in the member 21. Each bore rotatably supports a variable incidence nozzle vane assembly, shown generally at 31. A nozzle vane assembly firstly comprises a vane part 32 of aerofoil cross-section which projects across the annular passageway 33, which leads from the interior of the inlet scroll 18 to the periphery of the turbine rotor 11. The assembly further comprises a circular part 34 integral with the vane part 32, the left-hand face of which in the drawing forms part of the wall of the passageway 33. Part 34 being circular is rotatable in the bore 22, and is provided with a suitable sealing ring 35. Integral with the part 34 and extending to the right through the bore is a hollow stem 36 which projects into the annular chamber 27. This stem 36 is mounted for rotation in ball-bearings 37 and 38, sleeve members 39 and 40 being provided to space these bearings apart. Sleeve member 40 is a close fit in the bore 22 and the outer races of bearings 37 and 38 are a close fit in the sleeve member. A lever member 41 is fitted at the right-hand end of the stem 36, the stem and lever member being dowelled together as at 42. A unison ring 43 of channel cross-section is provided with twenty-five circumferentially equally spaced notches 44, each of these notches engaging with a pin 45 provided across the forks of each lever member

41. The unison ring 43 is angularly displaceable about the axis of the turbine rotor by means of an actuator (not shown), such angular displacement thus effecting variations in the incidence of the nozzle vanes 32. The actuator itself forms part of a conventional speed governing system.

The left-hand face of each nozzle vane 32 is arranged to be in engagement with an annular ring member 46 which is accommodated in an annular recess 47 provided in the left-hand wall of the passageway 33, that is, in the wall of the scroll part of the turbine casing. A small clearance 48 is provided between the outer diameter of the member 46 and the outer diameter of the recess 47, while a small clearance 49 is also provided between the inner diameter of the member 46 and the inner diameter of the recess 47. At its inner diameter on its left-hand face the member 46 is provided with a lip 50 which is turned in as shown to retain a large diameter Belleville washer 51 therewith.

It is arranged that upon assembly when the nozzle vanes are not engaged with the member 46, but when the Belleville washer is correctly seated as shown in the radially outer part of the recess, the member 46 stands 0.025 inches proud into the passageway 33.

When, however, the nozzles are fitted and engage the member 46, the member 46 is flush with the left-hand wall of passageway 33. Complete sealing at the tip and at the root of each nozzle vane is ensured, and by virtue of the limited movement of the member 46 which is permitted, distortion, to a relatively large extent, of the inlet scroll and/or of the vane assembly itself is accommodated, and thus normal variation of incidence of the vanes can continue in an unrestricted manner.

A number of passageways 52 place the interior of the inlet scroll in communication with the annular chamber 27 so that the nozzle vane adjusting means are all pressurised from the right-hand side in the drawing. In addition vane entry pressure acts on part of the left-hand face of each member 34, on part of the right-hand face of the member 46, and by virtue of the clearance 48 on substantially the whole of the left-hand face of the member 46. It also acts on the total area of the right-hand face of the Belleville washer 51. The actual pressure acting on the remaining areas of the left-hand face of the members 34 and the right-hand face of the member 46 is progressively less with movement across the vane by virtue of the pressure drop across the vane. In addition to the lower pressure acting across these remaining areas and by virtue of the clearance 49, the lower pressure also acts on a large proportion of the left-hand face of the Belleville washer 51.

The dimensions of the members 34, members 46, Belleville washer 51 and the effective area on the right-hand end of each nozzle actuating assembly together with the spring force in the Belleville washer are such that a resultant force of two pounds weight is exerted upon each nozzle assembly during normal operation, this force acting towards the left in the drawing, such that sealing at the tip of each vane is ensured.

When the air turbine unit is inoperative i.e. with all the vanes closed as shown in dotted lines in Figure 2, the sealing means are such that even the smallest leakage of air is not permitted, and thus the turbine rotor remains stationary.

In an alternative arrangement, not illustrated, the Belleville washer 51 may be omitted, and instead, two resilient ring members interposed between the left-hand face of the annular ring member 46 and the recess 47, both the annular ring member and recess having suitable grooves to retain these resilient ring members. The resilient ring members are provided with sufficient resilience to maintain the annular ring member in contact with the tips of the nozzle vanes, and at the same time, form a satisfactory seal behind the annular ring member.

The left-hand face of the annular ring member may be additionally pressurised through suitable passages placing this face in communication with the interior of the scroll part 18 of the turbine casing 16.

Alternatively, the resilience of the resilient ring members may be supplemented by the incorporation of suitable coil springs or the like, disposed between the annular ring member and the recess.

In the case where non-resilient ring members are employed, such coil springs or the like may provide the sole resilient means, in which case the ring members serve as sealing rings only.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.1.
Chartered Patent Agents.

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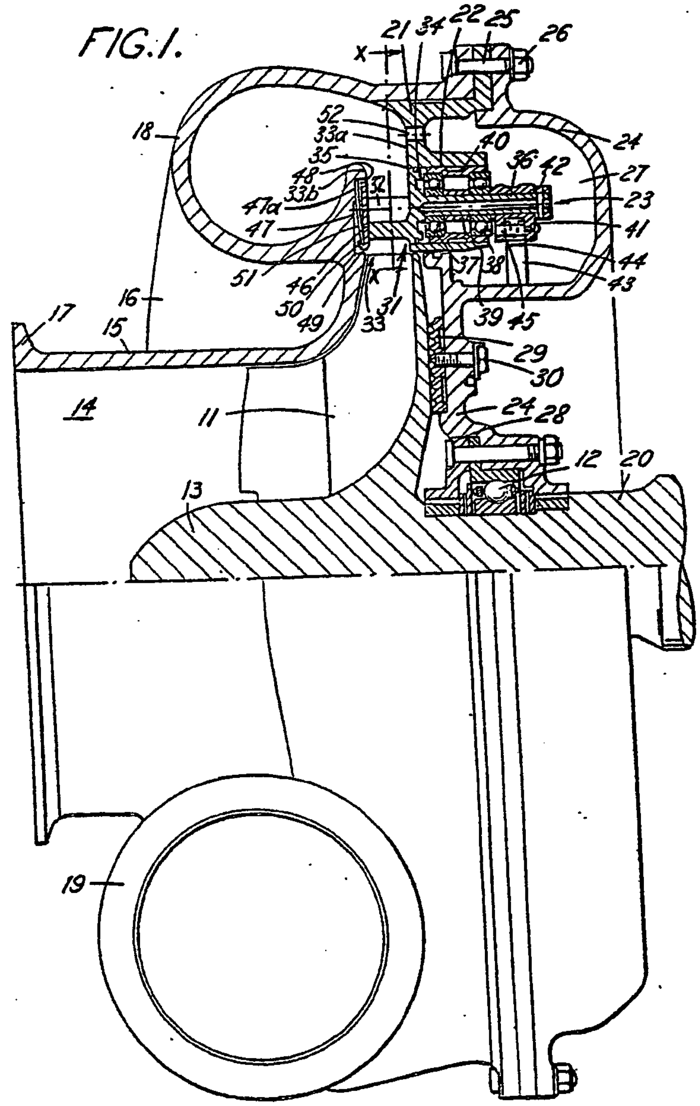
FIG. 1.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880903 PROVISIONAL SPECIFICATION

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Sheets 1 & 2

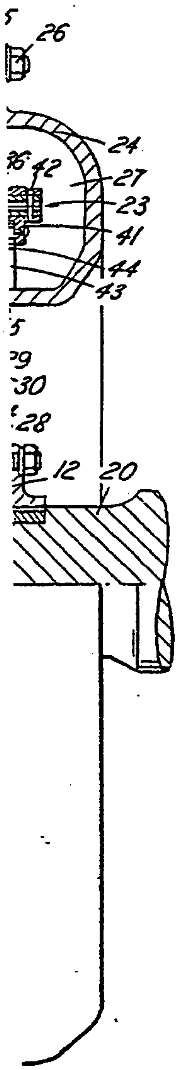
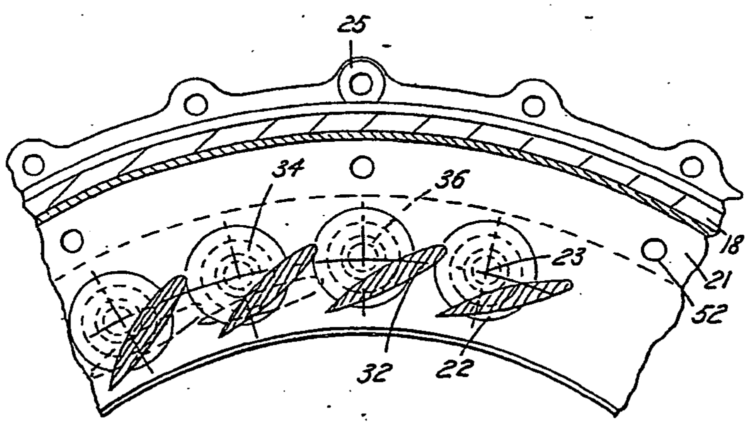


FIG. 2.



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2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 2

FIG. 1.

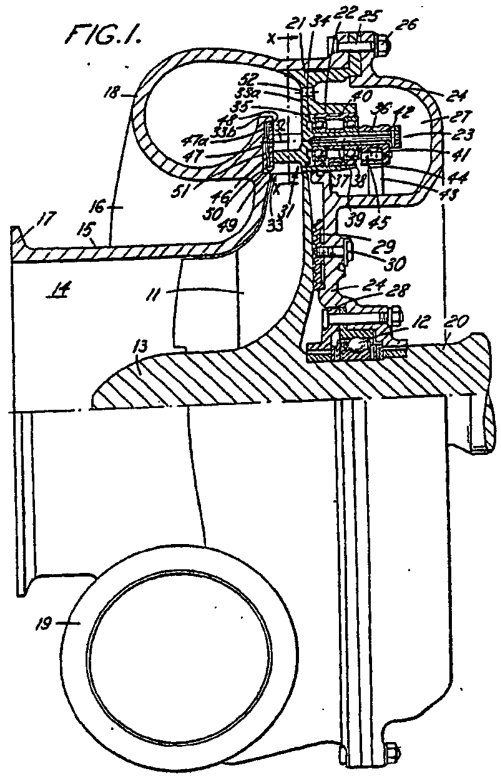

FIG. 2.